

NOISE-RESISTANT CIRCUIT AND APPARATUS USING SAME

BACKGROUND OF THE INVENTION

1 Technical Field of the Invention

5 The present invention relates generally to an on-vehicle airbag system for protecting occupants by inflating an airbag in a car upon collision.

2 Background Art

10 Cars are essential to modern life, and an airbag has also become essential for protecting occupant. A circuitry of a related airbag system (Japanese Patent First Publication No. 9-240416) is shown in Fig. 1. As shown, the airbag system 100 comprises a CPU (Central Processing Unit) 101, an IC (Integral Circuit) 102 having a first
15 switching element 106 and a second switching element 107, a mechanical safing sensor 103, an acceleration sensor 104 (hereinafter, simply referred to as "G-sensor") , a safing switching element 105, and a squib 120.

 A series of operation procedures upon collision is described
20 below. A signal from the mechanical safing sensor 103 is sent to the CPU 101 through an I/O circuit 108. If the CPU decides to choose ON, an approval signal is issued, and sent to an AND gate 110 through a signal line L100. The approval signal is also sent to an AND gate 111 through a signal line L101.

25 On the other hand, a detected signal from the G-sensor 104 is

sent to the CPU 101 through an A/D (Analog to Digital) converter 109.
If the CPU 101 chooses to squib, a driving signal is issued and sent to
the AND gate 111 through a signal line L102. If both of the driving
signal and the approval signal are sent to the AND gate 111, an AND
5 signal is sent to a SCI (Serial Communication Interface) 112 from the
AND gate 111. The AND signal is sent to the SPI (Serial Parallel
Interface) 113 through a serial transmission channel 119, and the AND
signal is sent to the AND gate 110 through a signal line L104. If
both of the AND signal and the approval signal are sent to the AND
10 gate 110, a safing switching element 105 is activated.

The driving signal is also sent to a SCI 114 through a signal line
L103. The driving signal is sent to a SPI 116 in the IC 102 through a
serial transmission channel 115. The driving signal from the SPI 116
is sent to a driving circuit 117 through a signal line L105. The first
15 switching element 106 is driven by the driving circuit 117. The
driving signal from the SPI 116 is also sent to a driving circuit 118
through a signal line L106. The second switching element 107 is
driven by the driving circuit 118. If the safing switching element 105,
the first switching element 106, and the second switching element 107
20 are all driven (that is, all of the elements are made ON), an electric
current flows in an electric power line L107. A squib 120 generates
heat on account of the electric current, and an inflator is fired up,
resulting in inflation of an airbag in a car.

However, the airbag system 100 has only one channel 115 to
25 connect the CPU 101 and the switching elements 106 and 107 in the
IC 102. (The channel 119 connects only the CPU 101 and the AND

gate 110.)

Because there is only one channel 115, if the channel 115 is effected by, for example, an external noise, it is likely to cause a problem on both of the first switching element 106 and the second
5 switching element 107 simultaneously. Thus, an operation reliability of the airbag system is low.

SUMMARY OF THE INVENTION

An airbag system of the present invention has been developed
10 considering the above issue in the background art. A purpose of the present invention is to offer the airbag system with a high operational reliability against, for example, an external noise.

In order to accomplish the above object, as one aspect of the present invention, there is provided a circuit configured to activate an
15 actuator comprising: a sensor sensing a predetermined physical event to provide a signal indicative of the event; a controller responsive to the signal inputted from the sensor to output actuator activating signals; a plurality of switch drivers responsive to the actuator activating signals outputted from the controller to produce switch
20 on-signals, respectively; a plurality of independent channels each of which connects the controller to one of the switch drivers to transmit the actuator activating signals from the controller to the switch drivers, respectively; and a plurality of switches designed to be turned on in response to the switch on-signals produced by the switch drivers,
25 respectively, the switches being so connected in series with each other that when the switches are all turned on, an actuator turning on-signal

being provided to activate the actuator.

Preferably, the actuator is a squib for inflating an airbag mounted on a vehicle.

As a second aspect of the present invention, there is provided an
5 airbag apparatus for safety comprising: an airbag inflating in response to a signal; a sensor sensing a movement and generating the signal in response to the movement; a controller configured to issue a command for squibbing the squib based on the signal; a plurality of drivers operating in response to the command; a plurality of independent
10 channels connecting the controller and the plurality of drivers to transmit the command from the controller to the plurality of drivers; and a plurality of switching elements, mutually connected in series and driven by the plurality of drivers respectively, to squib the squib.

The above configurations of the present invention can be
15 reduced into practice as follows.

An airbag system of the present invention is characterized by comprising a CPU, an IC having a plurality of switching elements for squibbing a squib in response to a command of the CPU, and a plurality of independent channels connecting the CPU and the IC
20 independently, for informing the command of the CPU to the plurality of switching elements for squibbing the squib.

Briefly, the airbag system of the present invention comprises a plurality of channels. In the airbag system of the present invention, if one of the channels is effected by an external noise, a problem is
25 caused only on the switching element which is informed of a squibbing command through the channel which is effected by the

external noise. In other words, the problem is not caused on the switching element connected to the other channel. As a result, a probability for causing the problem on all of the switching elements simultaneously becomes low. Because of the above reason, the airbag
5 system of the present invention has a high operational reliability against, for example, an external noise.

Optimally, the plurality of channels are a type of serial transmission system for giving the squibbing command. In other words, all of the channels of the present invention are the type of
10 serial transmission system. Interconnection of the serial transmission system is simpler than that of a parallel transmission system. This means that a circuitry of the serial transmission system becomes simpler than that of the parallel transmission system.

Optimally, the plurality of channels comprises a HI side
15 (potentially high side) channel and a LO side (potentially low side) channel. The HI side channel is connected to a higher voltage side of an electric power line for a squib, and the LO side channel is connected to a lower voltage side of it. A signal inputted from a sensor is processed by the CPU based on predetermined programs. A
20 HI side switching element driving signal with high voltage and a LO side switching element driving signal with low voltage are issued based on a result of processing carried out by the CPU. The HI side switching element driving signal transmits in the HI side channel, and drives the switching element connected electrically to the HI side
25 channel. Also, the LO side switching element driving signal transmits in the LO side channel, and drives the switching element

connected electrically to the LO side channel. With the above composition, a high operation reliability is realized even though the circuitry is simple in its configuration and the signal processing is also simple.

5 Optimally, at least, one of the HI side channel and the LO side channel has a plurality of routes for driving the plurality of switching elements in the above configuration.

With the above composition, the plurality of switching elements can be driven by the one channel. As a result, the circuitry becomes
10 simple if a plurality of airbags are set, for example, in front of a driver's seat, to the side of the driver's seat, in front of a passenger's seat and to the side of the passenger's seat.

Also, the HI side channel and the LO side channel are independent of each other in this configuration. Thus, a high
15 operation reliability is realized even if the channel is effected by, for example, an external noise.

Embodiments of the airbag system of the present invention are shown below.

20 BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiments of the invention, which, however, should not be taken to limit the invention to the specific
25 embodiment but are for the purpose of explanation and understanding

only.

In the drawings:

Fig. 1 is a circuit diagram of a conventional airbag system;

Fig. 2 is a block diagram showing an airbag system of a first
5 embodiment of the present invention;

Fig. 3 is a block diagram showing an airbag system of a second
embodiment of the present invention;

Fig. 4 is a block diagram showing an airbag system of a third
embodiment of the present invention; and

10 Fig. 5 is a block diagram showing an airbag system of a fourth
embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 (First embodiment)

First, an arrangement of an airbag system of a first embodiment
for automobile application will now be described. A block diagram
of the airbag system of the first embodiment is shown in Fig. 2. As
shown in Fig. 2, the airbag system 1 comprises a CPU 2, an IC 3, a
20 mechanical safing sensor 40, a G-sensor 41, a safing switching
element 50, and a squib 6.

The CPU 2 includes a first I/O circuit 20, an A/D converter 21,
a second I/O circuit 22, a HI side (potentially high side) SCI 23, and a
LO side (potentially low side) SCI 24. The first I/O circuit 20 is
25 connected to the mechanical safing sensor 40. The A/D converter 21
is connected to the electrical G-sensor 41. The second I/O circuit 22

is connected to a safing switching element driving circuit 51 which drives a safing switching element 50.

The IC 3 includes a HI side SPI 30, a LO side SPI 31, a HI side driving circuit 32, a LO side driving circuit 33, a HI side switching
5 element 34, and a LO side switching element 35. The HI side SPI 30, the HI side driving circuit 32 and the HI side switching element 34 are connected in series to each other. The LO side SPI 31, the LO side driving circuit 33 and the LO side switching element 35 are also connected in series to each other.

10 The HI side SCI 23 is connected to the HI side SPI 30 by a HI side serial transmission channel 70. The LO side SCI 24 is connected to the LO side SPI 31 by a LO side serial transmission channel 71.

The channels 70 and 71 are signal lines made of wires,
15 respectively. The each channel includes the wire and ports located at the both ends of the wire, that is, the SCI and SPI. A wireless channel using electromagnetic waves or rays is also possible.

The safing switching element 50, the HI side switching element 34, and the LO side switching element 35 are connected in series by
20 an electric power line L1. A squib 6 is positioned between the HI side switching element 34 and the LO side switching element 35. The squib 6 has a role of inflating an airbag mounted in front of the driver's seat.

An operating procedure of the airbag system upon collision in
25 the first embodiment will now be described. A signal from the mechanical safing sensor 40 is inputted to the CPU 2 through the first

I/O circuit 20. Alternatively, a signal from the G-sensor 41 is inputted to the CPU 2 through the A/D converter 21.

These signals are processed by the CPU 2 with predetermined programs. If the result of the processing carried out by the CPU 2
5 meets a predetermined condition, a safing switching element driving signal, a HI side switching element driving signal, and a LO side switching element driving signal are issued.

The safing switching element driving signal is sent to the safing switching element driving circuit 51 through the second I/O circuit 22.
10 If the safing switching element driving circuit 51 receives the safing switching element driving signal, the circuit 51 drives the switching element 50.

The HI side switching element driving signal is sent to the HI side driving circuit 32 through the HI side SCI 23, the HI side channel
15 70, and the HI side SPI 30. If the HI side driving circuit 32 receives the HI side switching element driving signal, the circuit 32 drives the switching element 34.

The LO side switching element driving signal is sent to the LO side driving circuit 33 through the LO side SCI 24, the LO side
20 channel 71, and the LO side SPI 31. If the LO side driving circuit 33 receives the LO side switching element driving signal, the circuit 33 drives the switching element 35.

If the safing switching element 50, the HI side switching element 34, and the LO side switching element 35 are driven, that is,
25 the all elements are made ON, an electric current flows in the electric power line L1. Thus, the squib 6 is caused to generate heat by the

current and then, an inflator is fired up, resulting in inflation of the airbag in the automobile.

Advantages of the airbag system of this embodiment can be described as below. In the case of airbag system 1 of this embodiment, if the HI side channel 70, that is, one of the HI side channel 70 and the LO side channel 71, is effected by an external noise, a problem resulting from the noise is caused only on the HI side switching element 34. However, such a problem is not caused on the LO side switching element 35. This means that a probability of simultaneously occurring problem on both of the HI side switching element 34 and the LO side switching element 35 is low. Because of this reason, a high operational reliability of the airbag system 1 of this embodiment is realized even if the airbag system 1 receives, for example, an external noise. The airbag system 1 of this embodiment uses the serial transmission system for both the HI side channel and the LO side channel, resulting in a simple circuitry of the airbag system 1.

(Second embodiment)

Referring to Fig. 3, an airbag system of a second embodiment according to the present invention will now be described. The difference between the first embodiment and the second embodiment is that the second embodiment includes two squibs contrasted with the single squib in the first embodiment. Accordingly, an IC includes two HI side (potentially high side) switching elements and two LO side (potentially low side) switching elements. Thus, only different

points from the first embodiment will be described below.

A circuitry of an airbag system of the second embodiment is shown in Fig. 3. Components corresponding to those of the first embodiment are shown with the same reference numbers in the first
5 embodiment.

An IC 3 includes a HI side SPI 30, a LO side SPI 31, a HI side first driving circuit 32a, a HI side second driving circuit 32b, a LO side first driving circuit 33a, a LO side second driving circuit 33b, a HI side first switching element 34a, a HI side second switching
10 element 34b, a LO side first switching element 35a, and a LO side second switching element 35b. The HI side SPI 30, the HI side first driving circuit 32a, and the HI side first switching element 34a are connected in series to each other. The HI side SPI 30, the HI side second driving circuit 32b, and the HI side second switching element
15 34b are also connected in series to each other. The LO side SPI 31, the LO side first driving circuit 33a, and the LO side first switching element 35a are connected in series to each other. The LO side SPI 31, the LO side second driving circuit 33b, and the LO side second switching element 35b are also connected in series to each other. A
20 squib 6a is positioned between the HI side first switching element 34a and the LO side first switching element 35a. The squib 6a has a role of inflating an airbag set in front of the driver's seat. A squib 6b is positioned between the HI side second switching element 34b and the LO side second switching element 35b. The squib 6b has a role of
25 inflating an airbag set in front of a passenger's seat.

If a safing switching element 50 is driven, and if the HI side

first switching element 34a is driven by the HI side first driving circuit 32a, and also if the LO side first switching element 35a is driven by the LO side first driving circuit 33a, an electric current flows in a electric power line L1. The squib 6a generates heat by the electric
5 current, and then, an inflator is fired up, resulting in inflation of the airbag in the automobile.

Also, if the safing switching element 50 is driven, and if the HI side second switching element 34b is driven by the HI side second driving circuit 32b, and also if the LO side second switching element
10 35b is driven by the LO side second driving circuit 33b, an electric current flows in the electric power line L1. The squib 6b generates heat by the electric current, and an inflator is fired up, resulting in inflation of the airbag in the automobile.

The airbag system 1 of the second embodiment has identical
15 advantages to that of the first embodiment. If the HI side channel 70, that is, one of the HI side channel 70 and the LO side channel 71, is effected by an external noise, a problem resulting from the noise is caused only on the HI side first switching element 34a and the HI side second switching element 34b. However, the problem is not caused
20 on the LO side first switching element 35a and the LO side second switching element 35b. This means that a probability of the problem occurrence on both of the HI side first switching element 34a and the LO side first switching element 35a simultaneously is low. Also, a probability of the simultaneous problem occurrence on both of the HI
25 side second switching element 34b and the LO side second switching element 35b is low. Because of the above reasons, a high operational

reliability of the airbag system 1 of this embodiment is realized even if the airbag system 1 receives, for example, an external noise.

In the airbag system 1 of this embodiment, the HI side first switching element 34a and the HI side second switching element 34b
5 are driven by the HI side channel 70. Also, the LO side first switching element 35a and the LO side second switching element 35b are driven by the LO side channel 71. Accordingly, a circuitry of this embodiment becomes simple compared with a configuration in which each switching element has its own channel.

10

(Third embodiment)

Referring to Fig. 4, an airbag system of a third embodiment according to the present invention will be described. The difference between the first embodiment and the third embodiment is that the
15 third embodiment has a mechanical safing sensor instead of both the safing switching element and the safing switching element driving circuit adopted in the first embodiment. Thus, only different points from the first embodiment will be described below.

A circuitry of an airbag system of the third embodiment is
20 shown in Fig. 4. Components corresponding to those of the first embodiment are shown with the same reference numbers in the first embodiment.

As shown in Fig. 4, the mechanical safing sensor 52 is connected to a HI side (potentially high side) switching element 34 and a LO side (potentially low side) switching element 35 in series to
25 each other through an electric power line L1. A signal from the

mechanical safing sensor 52 is sent to a CPU 2 through a second I/O circuit 22.

The airbag system 1 of the third embodiment has identical advantages to that of the first embodiment. Also, a circuitry of the CPU 2 for the airbag system 1 of the third embodiment becomes
5 simple.

(Fourth embodiment)

Referring to Fig. 5, an airbag system of a fourth embodiment
10 according to the present invention will now be described. The difference between the second embodiment and the fourth embodiment is that a safing switching element of the fourth embodiment is positioned in an IC. Thus, only different points from the second embodiment will be described below.

15 A circuitry of an airbag system according to the fourth embodiment is shown in Fig. 5. Components corresponding to those of Fig. 3 are shown with the same reference numbers of Fig. 3.

As shown in Fig. 5, a safing switching element driving signal is sent to a safing switching element driving circuit 51 through a safing
20 SCI 25, a serial transmission channel 72, and a safing SPI 36. A safing switching element 50 is driven by the safing switching element driving circuit 51.

An airbag system 1 of the fourth embodiment has identical advantages to that of the first embodiment. Also, in the fourth
25 embodiment, all of the switching elements are positioned in an IC 3, reducing assembly space in the airbag system 1.

(Modifications)

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics of it.

- 5 The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the present invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced
10 therein.

- The various embodiments of the airbag system have been explained. However, composition and configuration of the embodiment that can be adopted by the present invention are not limited to those explained in the above. It is possible for a person
15 skilled in the art to implement many other modified, or improved embodiments.

- For example, there is no limitation in the number of squibs. The number of the squibs will depend on the number of airbags. It is possible to increase the number of switching elements connected to
20 the HI side channel 70 and the LO side channel 71 respectively.

In addition, the airbag system of the present invention is applicable to many kinds of vehicles such as automobiles, motorbikes, carriages at amusement parks, and trains and airplanes.